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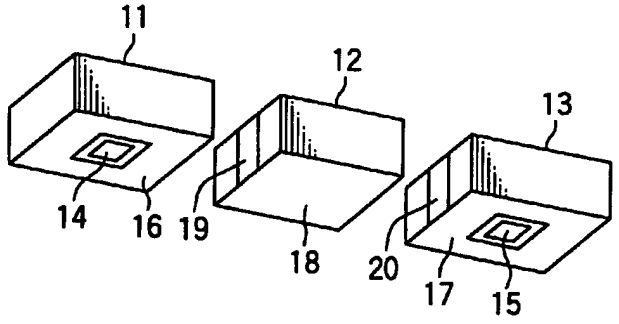
(54) Dielectric filter

(57) The present invention provides a small dielectric filter suitable for use in a high frequency band equal to or higher than 3 GHz. an input/output electrode made up of island type of conductive film is formed on one surface of said dielectric located on each end portion; in each of said dielectrics located on each end respectively, an earth electrode is formed on almost of all remaining area of said surface so as to be isolated from said input/output electrode and is also formed on all of the other surfaces with an exception of connecting surfaces; in an intermediate dielectric, an earth electrode is formed on all surfaces other than the connecting surface; and a conductive film connected to the earth electrode is formed on a part of at least one of the connecting surfaces of the dielectrics to be connected.Three or more elements of resonators may be integrally formed on a dielectric block, and, in that case, a through-hole is formed between the resonators.

FIG. 1



EP 1 024 548 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a dielectric filter and in particular to a small dielectric filter suitable for use in a high frequency band equal to or higher than 3 GHz.

PRIOR ART

[0002] With the spread of mobile communication device, a frequency band higher than that in current operation is considered to be made use of. In the conventional mobile communication, the frequency band up to about 2 GHz is used, and a combination of dielectric coaxial resonators has been mainly employed as a filter used in the mobile station.

[0003] When the dielectric coaxial resonator is used, however, in the frequency band equal to or higher than 3 GHz, an axial dimension thereof has to be made shorter due to the frequency, which makes it extremely thinner and also makes it difficult to form an input and output coupling. In addition, to secure high Q, an outer diameter of the dielectric shall be made larger. For example, in order to secure a Q required at a frequency of 5 GHz, 10-odd mm of outer diameter is necessary. This goes against a requirement for making an electronic unit smaller and is not practical. Instead of coaxial TEM mode resonator, TE mode resonator may be considered to be used, which results in larger size of structure and requires a complex structure of input and output coupling.

SUMMARY OF THE INVENTION

[0004] The object of the present invention is to provide a dielectric filter, which provides sufficient filtering characteristic at high frequency band, for example, within the range of 3 GHz to 30 GHz, and meets the requirement for high Q, downsizing and thinner thickness.

[0005] The present invention solves the problems in the prior art described above by employing an entirely new structure quite different from conventional ones.

[0006] That is, the present invention provides a dielectric filter composed of three or more rectangular parallelepiped dielectrics connected in line, said dielectric filter characterized in that:

an input/output electrode made up of island type of conductive film is formed on one surface of said dielectric located on each end portion;
in each of said dielectrics located on each end respectively, an earth electrode is formed on almost of all remaining area of said surface so as to be isolated from said input/output electrode and is also formed on all of the other surfaces with an exception of connecting surfaces;
in an intermediate dielectric, an earth electrode is formed on all surfaces other than the connecting surface; and
a conductive film connected to the earth electrode is formed on a part of at least one of the connecting surfaces of the dielectrics to be connected.

[0007] Three or more elements of resonators may be integrally formed on a dielectric block, and, in that case, a through-hole is formed between the resonators.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is an exploded perspective view of an embodiment according to the present invention;
Fig. 2 is an explanatory diagram illustrating a characteristic of a dielectric filter according to the present invention;
Fig. 3 is a perspective view of another embodiment according to the present invention;
Fig. 4 is an explanatory diagram illustrating a characteristic of another dielectric filter according to the present invention;
Fig. 5a is a plan view of another embodiment according to the present invention
Fig. 5b is a perspective view of the embodiment shown in Fig 5a;
Fig. 6 is an explanatory diagram illustrating a characteristic of a dielectric filter shown in Fig. 5 according to the present invention;
Fig. 7a is a plan view of another embodiment according to the present invention
Fig. 7b is a perspective view of the embodiment shown in Fig 7a;
Fig. 8 is an explanatory diagram illustrating a characteristic of a dielectric filter shown in Fig. 7 according to the present invention;
Fig. 9a is a plan view of another embodiment according to the present invention
Fig. 9b is a perspective view of the embodiment shown in Fig 9a; and
Fig. 10 is an explanatory diagram illustrating a characteristic of a dielectric filter shown in Fig. 9 according to the present invention;
wherein, each of reference numerals 11, 12, 13, 51, 52 and 53 designates a dielectric; 31 designates a dielectric (block); each of 14, 15, 34, 35, 54 and 55 designates an input/output electrode; each of 16, 17, 18, 36, 56, 57 and 58 designates an earth conductor; each of 19, 20 and 59 designates a conductive strip; each of 39 and 40 designates a through hole; and 99 designates a slit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] Though a resonance mode of a dielectric filter according to the present invention has not been completely analyzed, it is supposed that said dielectric filter operates just like a waveguide. It is supposed that an island type of electrode film formed on one surface of the dielectric is used as an input/output coupling structure and a coupling between the resonators is generated on a connecting surface or inside of the dielectric to make a filtering characteristic.

[0010] There will now be described a preferred embodiment of the present invention with reference to the attached drawings.

[0011] Fig. 1 is an exploded perspective view of an embodiment of the present invention illustrating a condition of a dielectric filter prior to being assembled. In this embodiment, three dielectric resonators are connected to make a unit. A rectangular parallelepiped dielectric 11, 13 with a dimension of 6.41 x 6.0 x 2.5 mm^3 and a dielectric constant of 37 is disposed on each end side respectively, and an island type of conductive film 14, 15 with a dimension of 1.4x1.4mm^2 is formed on a central portion of said 6.41 x 6.0 mm^2 surfaces respectively. A conductive film 16, 17 is formed surrounding said conductive film 14, 15 placing a distance of 0.5 mm therefrom, and a conductive film is also formed on all of other surfaces excepting a connecting surface to form an earth electrode by being connected to said conductive film 16, 17.

[0012] An intermediate dielectric resonator 12 has a dimension of 5.75 x 6.0 x 2.5 mm^3 and a conductive film 18 is formed on all the surfaces thereof excepting connecting surfaces to form an earth electrode. In the connecting portions of the dielectrics 11, 12, 13, though the dielectrics are exposed, conductive strips 19, 20 are formed thereon extending from the surface on which the input/output electrode being formed to the opposite surface thereof to adjust a coupling between the resonators. In this embodiment, 2 mm width of conductive strip is formed on a central portion of the connecting surface. In each of the connecting portions between the dielectric resonators 11, 13 each being located on each end respectively and the intermediate dielectric resonator 12 connected thereto, said conductive strip may be formed on either of the connecting surfaces. In this embodiment, for example, said conductive strip may not be formed on the resonator 11, and may not be formed also on an invisible connecting surface of the resonator 12. Thus, the conductive film may be formed on at least one of the connecting surfaces.

[0013] Fig. 2 is an explanatory diagram illustrating a characteristic of the dielectric filter made up by connecting the dielectrics shown in Fig. 1. It is shown that the center frequency is in 5.81 GHz, 3 dB bandwidth is 184 MHz, and an insertion loss at a peak point is 0.77 dB.

[0014] Fig. 3 is a perspective view of another embodiment of the present invention, in which three dielectric resonators are integrally formed on one dielectric block. In this embodiment, the dielectric block 31 has a dimension of 19.22 x 6.00 x 2.50 mm^3 and a dielectric constant of 37, and each of input/output electrodes 34, 35 is formed on each end portion on a surface of 19.22 x 6.00 mm^2 respectively, and a dielectric resonator having no input/output electrode is disposed in a central portion, and each of through holes 39, 40 is formed between said input/output electrodes and said central dielectric resonator for adjusting the coupling between the resonators.

[0015] Each of the through holes 39 and 40 is formed by a size of 1.6 x 0.5 mm^2 at a location of 6.37 mm apart from a longitudinal end surface of the dielectric block 31 respectively. Thereby, the dimension of the central dielectric resonator is defined to be 5.48 x 6.00 mm^2. An input/output electrode 34, 35 having a dimension of 1.4 x 1.4 mm^2 is formed on the surface of the dielectric on each end portion, and a conductive film 36 is formed on almost of all remaining area of said surface surrounding said input/output electrodes 34, 35 placing 0.5 mm of distance therefrom and also on all of other surfaces to form an earth electrode.

[0016] Fig. 4 is an explanatory diagram illustrating a characteristic of the dielectric filter obtained from the dielectric block shown in Fig. 3. It is shown that the center frequency is in 5.80 GHz, 3 dB bandwidth is 163 MHz, and an insertion loss at a peak point is 0.82 dB.

[0017] Though, in the embodiment shown in Fig. 3, the coupling is adjusted by the through hole formed between the resonators, a groove formed on a side surface of the dielectric block may be also employed for adjusting the coupling. Additionally, in case of connection shown in Fig. 1, a conductive film may be formed on both sides instead of conductive strip to expose the dielectric on the central portions.

[0018] As shown in above embodiments, a dimension of the dielectric forming the resonator located on each end portion shall be different from that of the dielectric forming the resonator located on the central portion. This comes from the difference therebetween in an effective dielectric constant, and thereby the dimension of the dielectric located on each end portion shall be larger than that on the central portion.

[0019] An arrangement of the dielectric resonators is not limited to the example shown above, but another structure including a bend therein may be also employed. Fig. 5 shows another embodiment of the invention, in which Fig. 5a is a plan view and Fig. 5b is an exploded perspective view illustrating a condition of a dielectric filter prior to being assembled. In this embodiment, three dielectric resonators are connected to make a unit. A rectangular parallelepiped dielectric 51, 52 with a dimension of 11.8 x 10.0 x 3.0 mm^3 is disposed on each end side respectively, and a circular island type of conductive film 54, 55 with a diameter of 4 mm is formed thereon respectively. A conductive film 56, 57 is formed surrounding said island type conduc-

tive film 54, 55 placing a distance of 0.5 mm therefrom, and a conductive film is also formed on all of other surfaces excepting a connecting surface to form an earth electrode by being connected to said conductive film 56, 57.

[0020] An intermediate dielectric resonator 53 has a dimension of 10.0 x 10.0 x 3.0 mm^3 and a conductive film 58 is formed on all the surfaces thereof excepting connecting surfaces to form an earth electrode. The dielectric resonator 53 is connected using adjacent two end surfaces thereof to the dielectric resonators 51 and 52 respectively. In the connecting portions of the dielectrics 51, 52, 53, the dielectrics are exposed and conductive strips 59, 60 are formed thereon extending from the surface on which the input/output electrode is formed to the opposite surface thereof to adjust a coupling between the resonators. In this embodiment, 3.40 mm width of conductive strip is formed on a central portion of the connecting surface. In each of the connecting portions between the dielectric resonators 51, 52 each being located on each end respectively and the intermediate dielectric resonator 53 connected thereto, said conductive strip may be formed on either of the connecting surfaces of two resonators to be connected. In this embodiment, for example, said conductive strip may not be formed on the resonator 51, and may not be formed also on an invisible connecting surface of the resonator 52. Thus, the conductive film may be formed on at least one of the connecting surfaces.

[0021] Fig. 6 is an explanatory diagram illustrating a characteristic of the dielectric filter made up by connecting the dielectrics shown in Fig. 5. It is shown that the center frequency is in 3.41 GHz, 3 dB bandwidth is 99.1 MHz, and an insertion loss at a peak point is 0.83 dB.

[0022] Fig. 7 includes a plan view and a perspective view of another embodiment of the present invention, in which four dielectric resonators are connected so as for the dielectric resonators on respective input/output ends thereof to be disposed adjacently with each other. In this embodiment, the dielectric resonators on respective input/output ends thereof are formed to be a dimension of 11.2 x 10.0 x 3.0 mm^3 and two intermediate ones to be of 10.0 x 9.5 mm^2. As for the conductive films for adjusting the coupling, the conductive film between intermediate dielectric resonators is set to be as wide as 3.8 mm and that between the resonator on the input/output end and the intermediate resonator is set to be as wide as 3.4 mm.

[0023] Fig. 8 is an explanatory diagram illustrating a characteristic of the dielectric filter made up by connecting the dielectrics shown in Fig. 7. It is shown that the center frequency is in 3.50 GHz, 3 dB bandwidth is 110.2 MHz, and an insertion loss at a peak point is 1.05 dB.

[0024] In Fig. 9, four elements of dielectric resonators each having the same dimension as that shown in Fig. 7 are connected, in which resonators 91 and 92 located on input/output ends are brought into capacitive coupling. That is, a slit 99 exposing the dielectric is formed on the connecting surface of the resonators 91 and 92 each being located on the input/output ends respectively. The characteristic with the slit as wide as 0.005 mm is shown in Fig. 10. There is no change in the center frequency, 3 dB band width and the insertion loss, but extremes P1 and P2 of damping curve are formed on each side of pass band, which provides a steep damping characteristic.

[0025] Thus the dielectric resonators are brought into capacitive coupling by this slit 99 to provide polarity. When the structure in which the dielectric resonators are bent and connected is employed, the input and output ends are placed adjacently with each other, so that they may be connected without any additional element.

[0026] As shown in above embodiments, a dimension of the dielectric forming the resonator located on each end portion shall be different from that of the dielectric forming the resonator located on the central portion. This comes from the difference therebetween in an effective dielectric constant, and thereby the size of the dielectric located on each end portion shall be larger than that on the central portion. In above embodiment, the dielectric constant of each dielectric is 37.

[0027] According to the present invention, a small and thin dielectric filter capable of being used in a frequency band width equal to or more than 3 GHz may be provided. In addition, an easily producible and inexpensive dielectric filter may be provided since it can be made by merely forming a conductive film on a surface of the rectangular parallelepiped dielectric.

[0028] Further, the frequency of extreme may be arbitrarily set since the dielectric resonators located on the input/output end portions can be brought into capacitive coupling depending on the arrangement thereof and, in addition, the coupling condition thereof can be easily adjusted.

Claims

1. A dielectric filter composed of three or more rectangular parallelepiped dielectrics connected in line, said dielectric filter characterized in that:

   in each of the dielectrics located on each end portion respectively, an input/output electrode made up of island type of conductive film is formed on one surface thereof, and an earth electrode is formed on almost of all remaining area of said one surface so as to be isolated from said input/output electrode and is also formed on all of the other surfaces with an exception of connecting surface;
   in each of the intermediate dielectrics, an earth electrode is formed on all surfaces other than the connecting surfaces thereof; and
   a conductive film connected to the earth electrode is formed on a part of at least one of the

connecting surfaces of the dielectrics to be connected.

2. A dielectric filter in accordance with claim 1, in which said conductive film connected to the earth electrode is a conductive strip for connecting the earth electrode on the surface on which the input/output electrode is formed to the earth electrode on the surface opposite thereto.

3. A dielectric filter in which three or more resonators are integrally formed in a rectangular parallelepiped dielectric block, said dielectric filter characterized in that:

in each of the dielectric resonators respectively located on each end portion of said dielectric block with respect to a longitudinal direction thereof, an input/output electrode made up of island type of conductive film is formed respectively on the same surface of said dielectric block, and an earth electrode is formed on almost of all remaining area of said same surface so as to be isolated from said input/output electrode and is also formed on all of the other surfaces;
in each of the other dielectric resonators, an earth electrode made up of conductive film is formed on all surfaces thereof; and
between the dielectric resonators, a through hole extending from the surface on which the input/output electrode is formed to the surface opposite thereto is formed.

4. A dielectric filter composed of three or more rectangular parallelepiped dielectrics connected, said dielectric filter characterized in that:

in each of the dielectrics located on each end portion respectively, an input/output electrode made up of island type of conductive film is formed on one surface thereof, and an earth electrode is formed on almost of all remaining area of said one surface so as to be isolated from said input/output electrode and is also formed on all of the other surfaces with an exception of connecting surface;
in each of the intermediate dielectrics, an earth electrode is formed on all surfaces other than the connecting surfaces thereof;
a conductive film connected to the earth electrode is formed on a part of at least one of the connecting surfaces of the dielectrics to be connected; and
at least one of said intermediate dielectrics is connected to other dielectrics at adjacent end surfaces.

5. A dielectric filter in accordance with claim 4, in which said conductive film connected to the earth electrode is a conductive strip for connecting the earth electrode on the surface on which the input/output electrode is formed to the earth electrode on the surface opposite thereto.

6. A dielectric filter in accordance with claim 4 or 5, in which said dielectrics located in input/output end portions respectively are disposed adjacently with each other.

7. A dielectric filter in accordance with any of the claims 4 to 6 in which said dielectrics located in input/output end portions respectively are brought into capacitive coupling.

FIG. 1

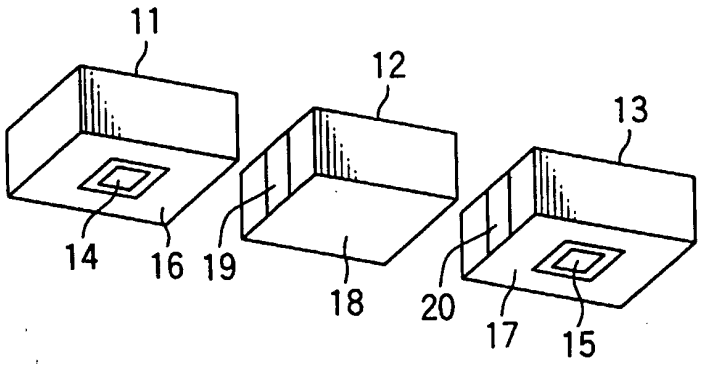

11
12
13
14
16
19
18
20
17
15

FIG. 2

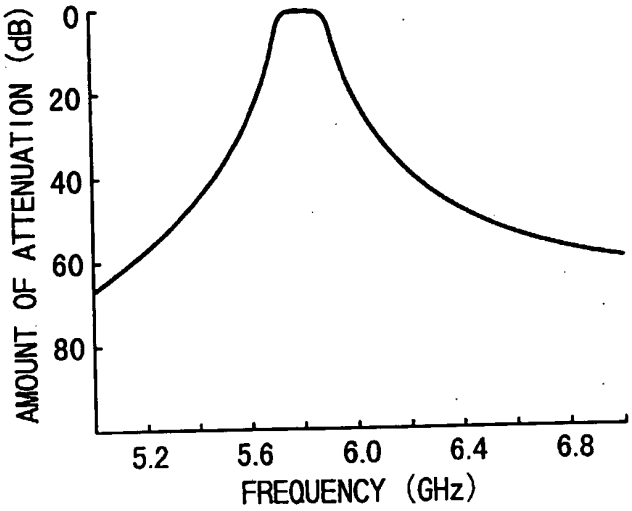

AMOUNT OF ATTENUATION (dB)
0
20
40
60
80
5.2
5.6
6.0
6.4
6.8
FREQUENCY (GHz)

FIG. 3

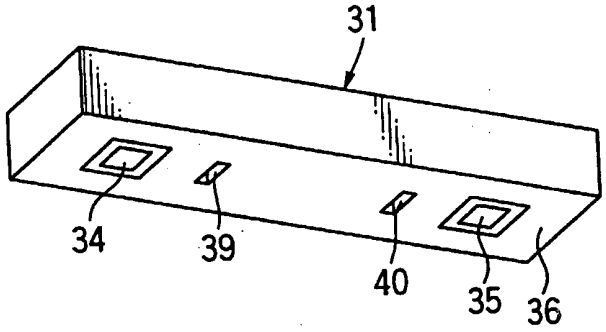

31
34
39
40
35
36

FIG. 4

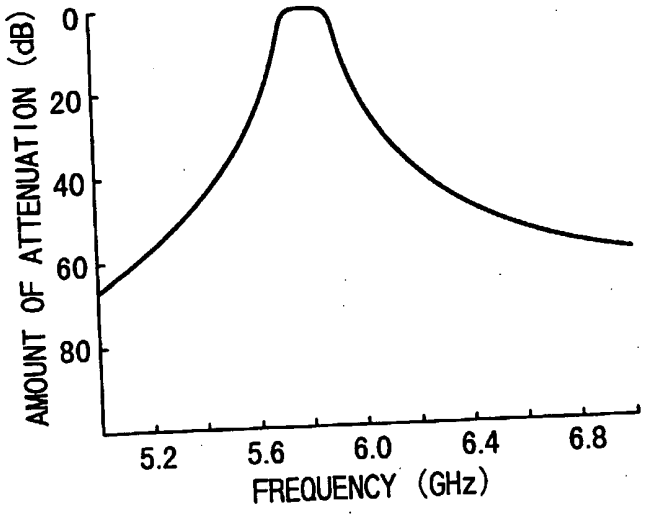

AMOUNT OF ATTENUATION (dB)
0
20
40
60
80
5.2
5.6
6.0
6.4
6.8
FREQUENCY (GHz)

FIG. 5(a)

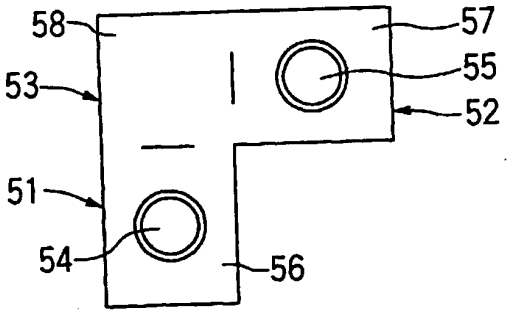


FIG. 5(b)

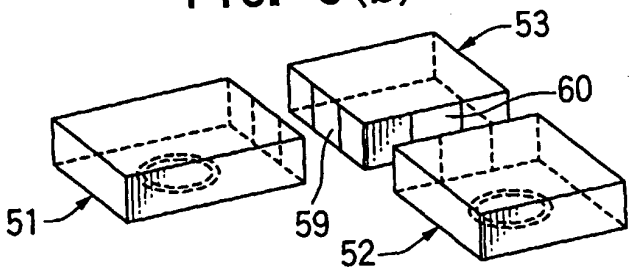


FIG. 6

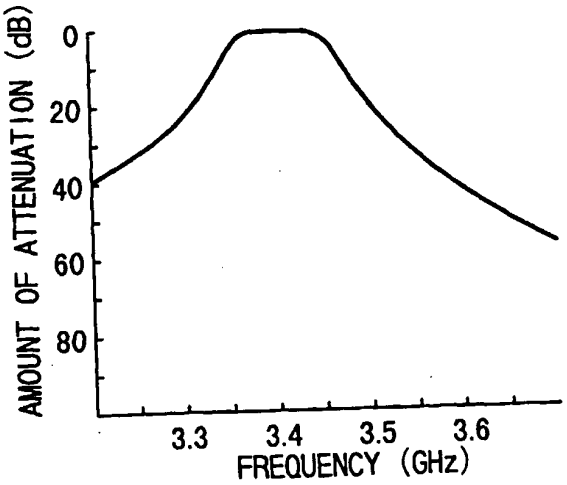


FIG. 7(a)

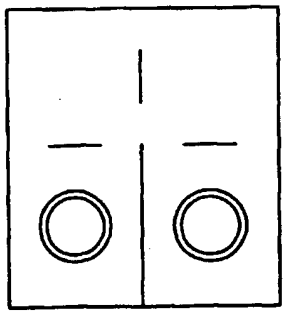


FIG. 7(b)

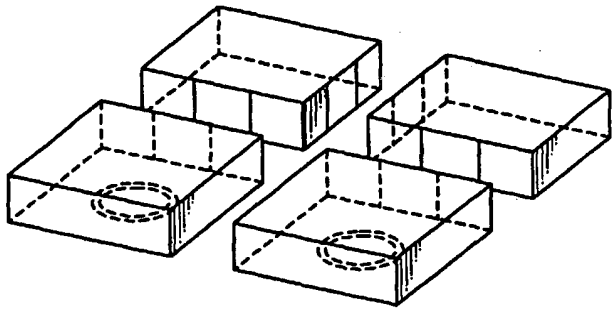


FIG. 8

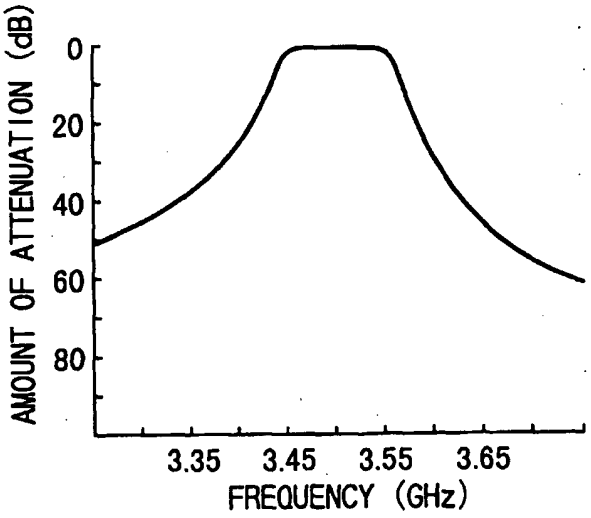


FIG. 9

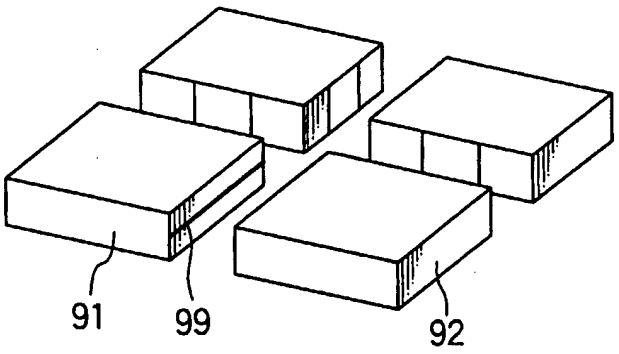
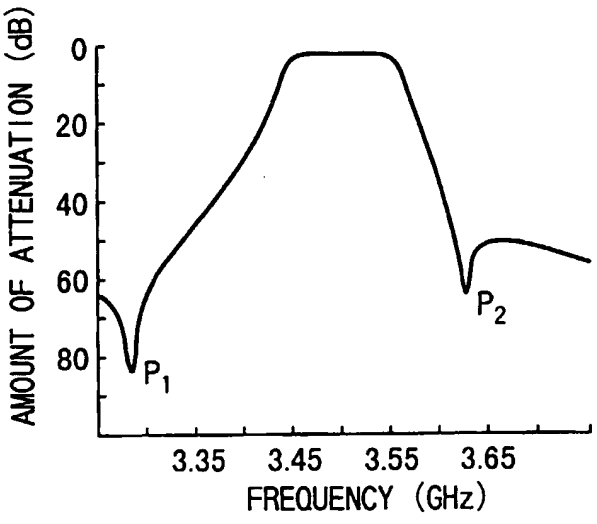

91
99
92

FIG. 10


AMOUNT OF ATTENUATION (dB)
0
20
40
60
80
P1
P2
3.35
3.45
3.55
3.65
FREQUENCY (GHz)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 10 1719

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 859 423 A (MURATA MANUFACTURING CO. LTD.) 19 August 1998 (1998-08-19) * column 1, line 15 - column 2, line 33 * * column 4, line 58 - column 6, line 19 * * column 12, line 12 - line 28; figures 1,2,16,17,22-25 *	1,3	H01P1/207
Y	---	4	
Y	EP 0 525 416 A (ANT NACHRICHTENTECHNIK) 3 February 1993 (1993-02-03) * column 1, line 43 - column 2, line 8; figure 1 *	4	
X	---	1,3	
A	EP 0 856 902 A (MURATA MANUFACTURING CO. LTD.) 5 August 1998 (1998-08-05) * the whole document *	4	
P,X	---	1,2	
	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) -& JP 11 225004 A (TOKO INC), 17 August 1999 (1999-08-17) * abstract; figure 7 *		TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01P
L	*priority*		
P,X	---	1,2	
	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) -& JP 11 195905 A (TOKO INC), 21 July 1999 (1999-07-21) * abstract; figures 1,3,5,7 *		
L	*priority*		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	3 May 2000	Den Otter, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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03-05-2000

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82